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COLLABORATIVE RESEARCH DEVELOPING, TESTING AND VALIDATING BRAIN ALIGNMENT ALGORITHM USING GEOMETRIC ANALYSIS

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Final Report

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This is the final report by the University of Southern California on a AFSOR grant, part of a joint program with Harvard University (PI, Shing-Tung Tau), "Collaborative Research Developing, Testing and Validating Brain Alignment Algorithm using Geometric Analysis" (grant # FA9550-10-1-0362). The task assigned to USC in our component of the grant was to provide testing material for the development of an algorithm to align brains (the development of the algorithm was the task assigned to Harvard University). Finally, we were to test and validate the algorithm once it had been developed.

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Collaborative Research Developing, Testing and Validating Brain alignment algorithm using Geometric Analysis

FINAL REPORT

PI: Hanna Damasio, MD

University of Southern California

This is the final report by the University of Southern California on a AFSOR grant, part of a joint program with Harvard University (PI, Shing-Tung Tau), "Collaborative Research Developing, Testing and Validating Brain Alignment Algorithm using Geometric Analysis" (grant # FA9550-10-1-0362). The task assigned to USC in our component of the grant was to provide testing material for the development of an algorithm to align brains (the development of the algorithm

was the task assigned to Harvard University). Finally, we were to test and validate the algorithm once it had been developed.

We provided, during the first year, an initial sample of 6 normal brains scanned in a Siemens scanner at 1.5T, ages 28 to 73. The brains were extracted from all non-brain tissue, together with images of the slices which were all thin cut, consecutive, acquired coronally. Furthermore, we extracted segmented volumes of the whole brain, of the right and left hemispheres, and of the right and left insula and cingulate gyri, for all 6 brains. This was the material to be used in the development of the algorithm.

During year 2, 20 additional brains were used to test the preliminary algorithm. A report of the results was presented at the IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR), Portland, Oregon, June, 2013, and the 35th Annual Meeting of the Cognitive Science Society, Austin, TX. The reports have been published. [ShiR, Zeng W, Su Z, Damasio H, Lu Z, Wang Y, Yau S-T, Gu X, Hyperbolic Mapping for Constrained Brain Registration, IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR), Portland, Oregon, June 2013; Gu H, Myung J I, Pitt M A, Lu Z-L, Bayesian Adaptive Estimation of Psychometric Slope and Threshold with Differential Evolution, Cooperative Minds:Social Interaction and Group Dynamics, proceedings of the 35th Annual Meeting of the Cognitive Science Society, Austin, TX: Cognitive Science Society, pg 2452-2457.]

At this time we have a total of 80 brains of normal subjects from our Brain Registry, all scanned in a 1.5T Siemens Scanner, and ready to be used for validation of any algorithm.

We also have 40 brain scans of normal adult East-Asian Chinese subjects, scanned under a different project in a 3T Siemens Scanner. They too are available for processing and use once the final algorithm becomes available.

During year 3, the last period of funding, although we did not yet have the final algorithm available for testing, we scanned 10 additional normal young adults, at USC, on a 3T Siemens Scanner, both with structural MR sequences and fMR sequences, so as to have a final combined structural and functional set of data to test the algorithms.

The pulse sequences used for these scans were as follows:

High resolution whole-brain T1 weighted sequence using TR = 2350 ms, TE = 3.09 ms, 256 x 256 mm, 208 slices, slice thickness of 1 mm, resolution of 1 mm^3, flip angle = 10°.

High angular resolution diffusion weighted imaging sequence using HARDI; TR=8742 ms, TE=115 ms, b=2500 s/mm2, 144-directions, b=2500, collected over 2 runs of 86 and 65 directions, including 6 b=0 volumes.

T2*-weighted gradient echo, echo planar imaging, rest and functional (active hand movement) sequences using TR=2000 ms, TE=30 ms, 37 slices, voxel size 3.5×3.5×3.5 mm, flip angle 90°, 158 volumes.

These Brains are ready to be used in the validation of the different algorithm(s) to be developed by the University of Harvard group.

While waiting for the final algorithm(s) to be developed and tested under this project, we began analyzing the data obtained here at USC using a recently developed program known as BrainSuite. This program is aimed at extracting, segmenting, aligning, and transfering ROIs (Regions Of Interest), and has been developed as a collaboration between USC and UCLA, in which I have been involved. Once we receive the alignment algorithm(s) developed by the Harvard group we will be able to test the validity of the new algorithm(s), and to compare the results to those obtained with BrainSuite. This is a welcome possibility that was not contemplated or proposed in the original grant.